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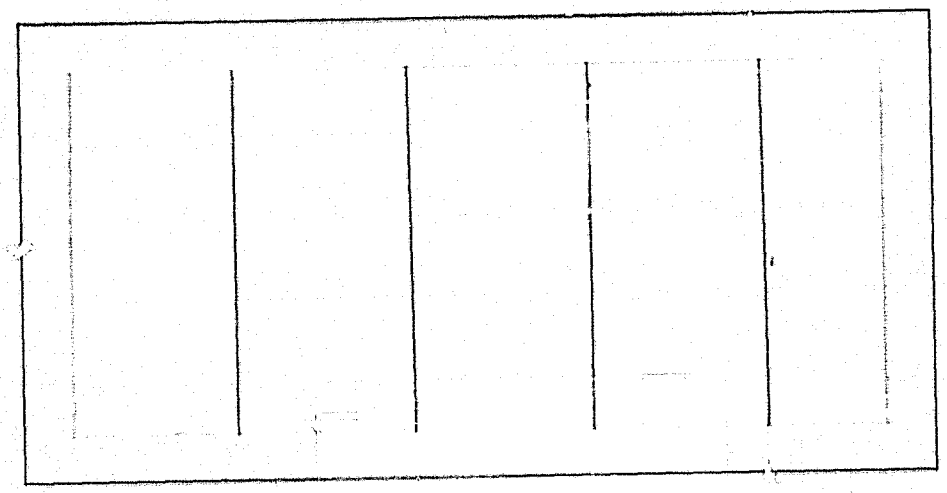

SCIENCE APPLICATIONS INCORPORATED

(E76-10349) DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE FROM LANDSAT DATA
Progress Report, 1 Feb. - 30 Apr. 1976
(Science Applications, Inc.) 14 p HC $3.50
CSCL 04A G3/43

N76-24669

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MAY 24 1976
SIS/902.6

SAI-76-595-LJ
May 1, 1976

DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE FROM LANDSAT DATA

Progress Report No. 5

Contract No. NAS5-20899

I. D. Number 22260

Period Covered: February 1 to April 30, 1976

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Goddard Space Flight Center

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ACCOMPLISHMENTS

In this fifth reporting period, Volz measurements were made at both test sites, new test sites were established in an expansion of the program, and analysis of the raw data CCT's was continued.

New Test Sites

During this reporting period the scope of work of the program was increased to obtain data at other sites, in order to confirm the general application of the technique to different bodies of water and different aerosol types. The additional sites include seven NOAA-EPA turbidity network stations, and four sites in the NASA-LACIE study to monitor wheat growing areas. These sites are listed in Table 1. Mr. E. Flowers of NOAA-EPA has arranged for observers at the turbidity network sites to make special Volz readings at the times of Landsat 1 and 2 overpasses. Dr. D. Pitts of NASA-Houston will supply the Volz data which are routinely taken at the LACIE sites at the time of Landsat 2 overpasses.

Volz Measurements

In this period it was possible to obtain Volz data for two of the five Landsat 2 overpasses at the San Diego test site. Three trips were made to the Salton Sea test site but good data were obtained on only two occasions due to cloud cover. Data were also obtained for four of the five Landsat 1 overpasses at San Diego in this period. The measured Volz data are given in Table 2.

TABLE 1. New Test Sites

NOAA-EPA Sites		
Barrow, Alaska	71°20'N	156°37'W
Grand Prairie, Texas	32°42'N	97°01'W
Miami, Florida	25°44'N	80°10'W
Atlantic City, New Jersey	39°27'N	74°34'W
Kadena AB, Okinawa	26°21'N	127°46'E
Anderson AB, Guam	13°34'N	144°55'E
Adrigole, Ireland	51°24'N	9°27'W
LACIE Sites		
Burke Co. N. Dakota	48°53'N	102°10'W
Divide Co. N. Dakota	48°53'N	103°11'W
Toole Co. Montana	48°53'N	111°47'W
Hill Co. Montana	48°42'N	109°55'W

TABLE 2. Volz Data

Date	Aerosol Optical Thickness	Aerosol Content
Landsat 2		
San Diego		
4-11-76	.220	1.02N
4-29-76	.285	1.34N
Salton Sea		
3-23-76	.166	.77N
4-10-76	.240	1.12N
Landsat 1		
San Diego		
2-26-76	.174	.81N
3-15-76	.230	1.07N
4-2-76	.245	1.14N
4-20-76	.270	1.26N

Landsat Data

Digital data for five Landsat 2 overpasses at San Diego and the Salton Sea have been received and analyzed. In addition, four Landsat 1 CCT's for Atlantic City, Grand Prairie and Miami were received and analyzed. Volz data for these latter three sites were obtained by the NOAA-EPA turbidity network at the time of Landsat overpasses in August, September and October 1975.

The radiance data analyzed to date for Landsat 2 are shown in Figure 1 as a function of aerosol content, in comparison with the previous Landsat 1 relationships. It is seen that MSS 4 continues to show lower radiance values than those of Landsat 1. MSS 5 continues to show values close to those of Landsat 1, although three of the last six data points analyzed appear higher than expected. MSS 6 and 7 continue to be quite different from Landsat 1; the usefulness of the raw data tapes in resolving these differences are discussed in this report.

The Landsat 1 data from the other three sites are presented in Figure 2 with previous Landsat 1 data. The Miami data are consistent with the previous Miami data discussed in Progress Report No. 2, showing fair agreement in MSS 6 and 7, but not in MSS 4 and 5 (due to water pollution). On these particular dates at Miami the agreement for MSS 6 and 7 is better if the radiance is measured over the ocean about 5 miles each of the Volz site where the water is clearly less polluted. On these dates the wind was 14 knots from the east, so that the aerosol content measured at the Volz site is probably representative of the air 5 miles east. Thus the higher than expected radiance values in MSS 6 and 7 near the Volz site can probably be attributed to water pollution. The Atlantic City radiances, which were measured over a reservoir

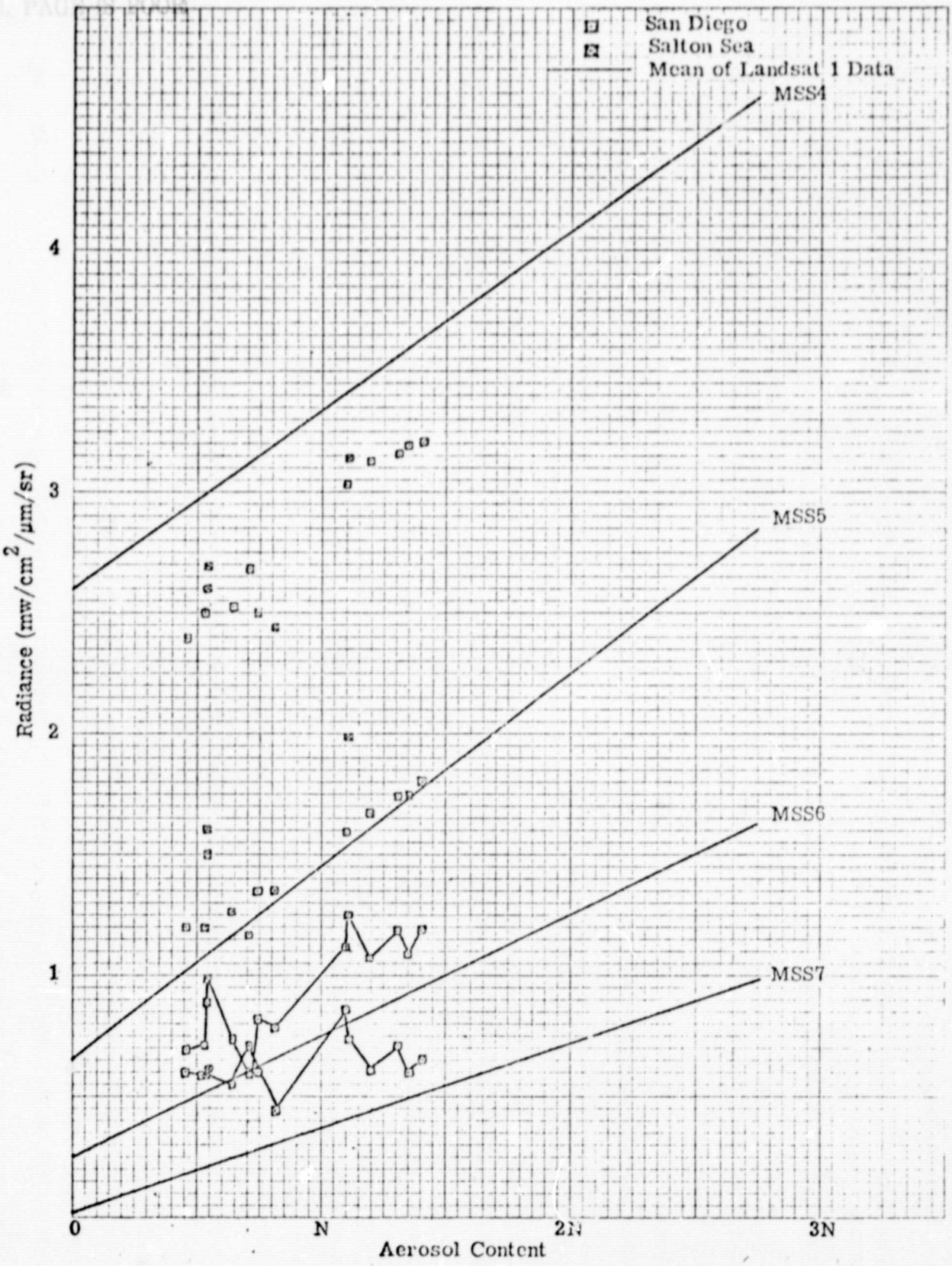

Figure 1. Radiance vs. Aerosol Content (Landsat 2)

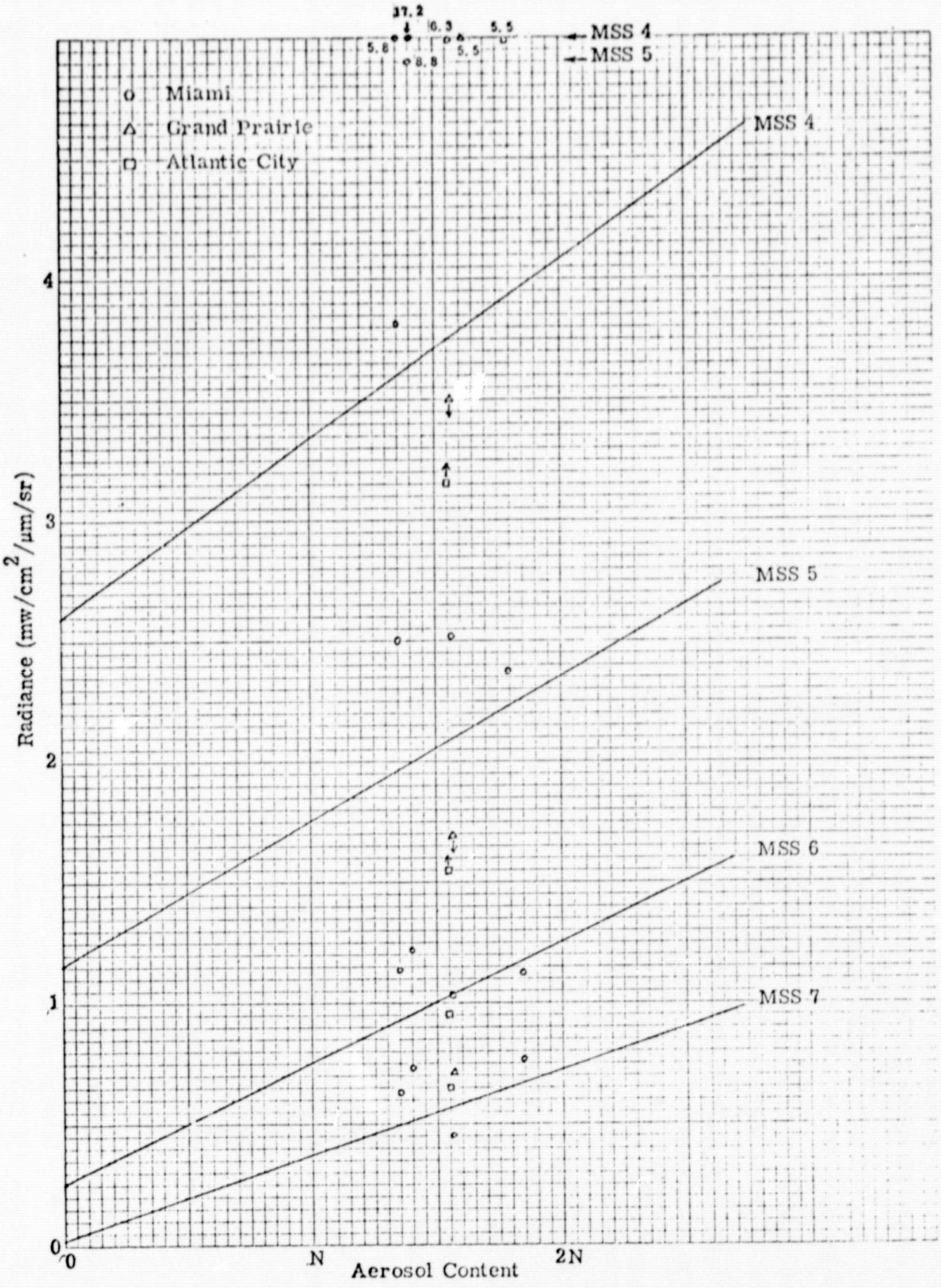

Figure 2. Radiance vs. Aerosol Content (Landsat 1)

near the Volz site, rather than over the ocean or a large body of water, show excellent agreement in MSS 6 and 7, but differ significantly in MSS 4 and 5, being lower than expected. These lower values are not immediately accounted for since water pollution would cause higher values. Also, any possible effects of the adjacent land surface with higher reflectivity would produce higher values. Clearly more data points at this site are necessary to determine the reliability of this one set. The Grand Prairie data obtained over a lake near the Volz site look good only for MSS 7, with the other bands exhibiting high radiance values. The B&W prints of these data did show considerable water pollution in the lake.

Raw Data Tapes

Three raw data tapes have been received from GSFC, and analyzed, based on information obtained from G. Grabowski at GSFC. The relationships between the pixel counts and radiance are given by

$$V_u = \alpha + \beta \frac{(R - R_{min})}{(R_{max} - R_{min})} \qquad (1)$$

$$V_c = 128 \frac{(R - R_{min})}{(R_{max} - R_{min})} \text{ for MSS4, 5, 6}$$

$$V_c = 63 \frac{(R - R_{min})}{(R_{max} - R_{min})} \text{ for MSS7} \qquad (2)$$

Hence

$$V_c = \frac{128}{\beta}(V_u - \alpha) \quad \text{MSS 4, 5, 6}$$

$$V_c = \frac{63}{\beta}(V_u - \alpha) \quad \text{MSS 7} \tag{3}$$

where

V_u	is the uncalibrated digital voltage
V_c	is the calibrated digital voltage
R_{max}	is the specified maximum radiance
R_{min}	is the specified minimum radiance
R	is the measured radiance
α	is the detector offset
β	is the detector gain.

From Equation (3) it can be seen that if $V_u < \alpha$ then V_c is negative. When this occurs V_c is assigned the value zero, i. e., all negative values of V_c are assigned the value zero, and radiance information is lost at low radiance values.

In order to analyze the raw data tapes our processing technique was reprogrammed to print out the calibration data, which include α and β, at the end of each scan line. These values, which are

different for each of the 24 detectors (6 per MSS channel), are used with Equation (1) to compute the raw radiance for each pixel.

The results for the first raw data tape (3-30-75 San Diego overpass) are shown in Figure 3 in comparison with the radiances obtained previously from the corrected data tape. It is seen for MSS 7, where the radiance differed the most from the expected value, that the raw radiance value falls exactly as expected, suggesting that the raw tapes will resolve the apparent discrepancies in the MSS 6 and 7 radiances. The raw radiances for MSS 5 and 7 are not greatly different from the corrected values, although the MSS 4 value is significantly lower than the corrected radiance.

The second raw tape (5-5-75 San Diego overpass) was analyzed, and it was found that the pixel counts of the raw and corrected tapes were generally identical and did not differ by more than one count. This was in contrast to the first raw tape which was clearly different from the corrected tape. In addition, for one scan line of the MSS 4 in the 5-5-75 raw data $V_u = 1.0$ and $\alpha = 1.7$, and hence $(V_u - \alpha)$ is negative and V_c should be zero in the corrected data. However $V_c = 2.0$. In another scan line $(V_u - \alpha)$ is again negative, but $V_c \neq 0$, and in fact $V_c = V_u$. These discrepancies suggest that something is wrong with this raw tape.

The third raw tape (11-18-75 Salton Sea) was processed, but the values of α and β were both zero, which are not meaningful. Hence no further analysis of this tape was made.

Several telephone discussions about these raw tapes were held with G. Grabowski at GSFC, but the data on the second and third tapes could not be explained, except to suppose that some error was made

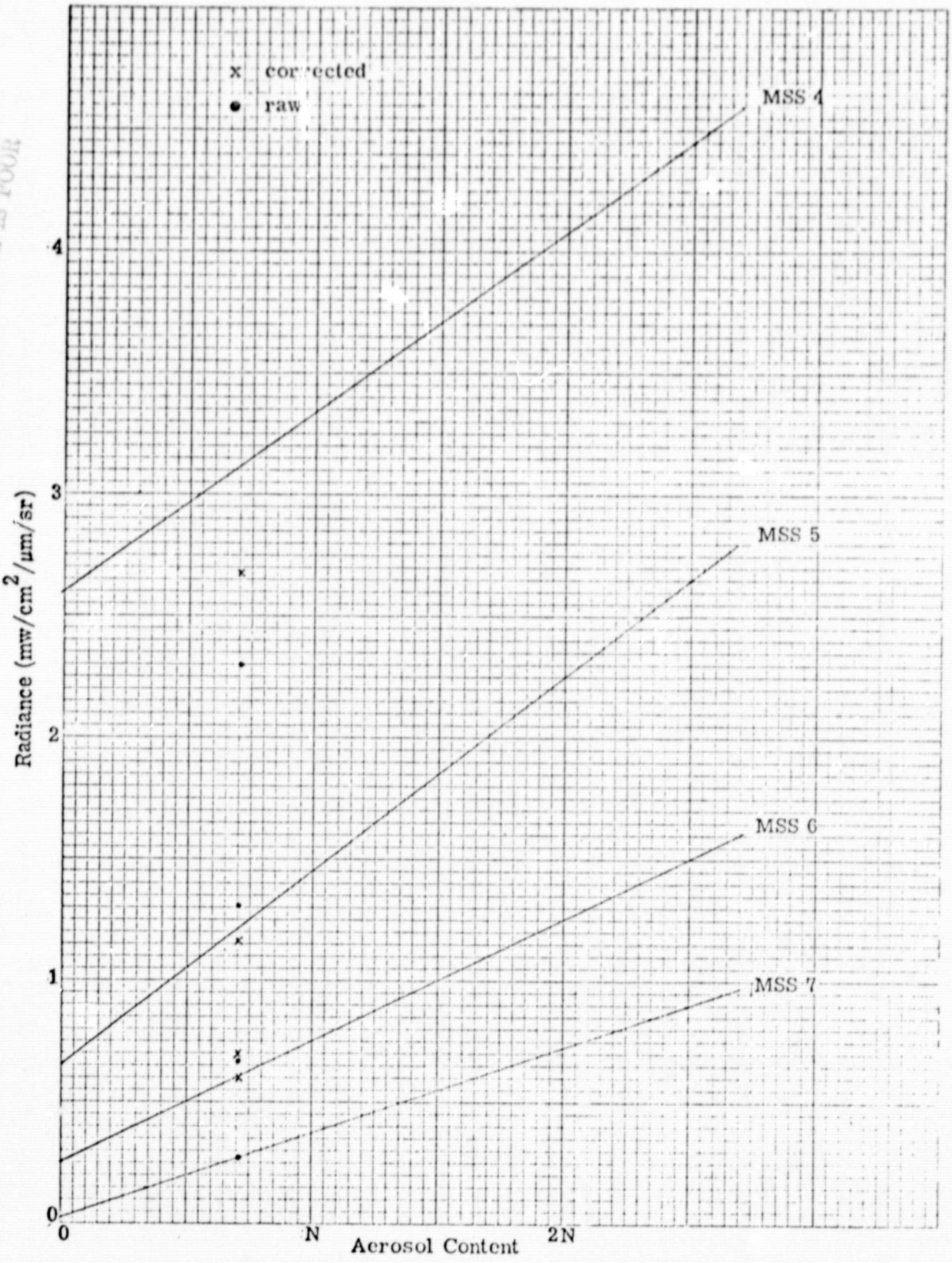

Figure 3. Comparison of Raw and Corrected Radiances

by the processor in generating the tapes. Of course, if this is possible, then doubt is cast on all received data.

Theoretical Calculations

In Progress Report No. 4 it was stated on page 4 that changes in the refractive index of the particles are more significant than changes in their vertical distribution. The change in refractive index referred to was the change from zero imaginary component to 0.01 imaginary component, i.e., the addition of absorption by the particles. As discussed in Progress Report No. 2, it is believed that the particulate absorption is not significant in most of our data since both silicate and sodium chloride particles have zero imaginary component in their refractive index. It is hoped to make calculations to investigate the effect of changing the real part of the refractive index.

Plans

Volz data will be taken at San Diego and the Salton Sea, weather permitting. Volz data and Landsat data from the new test sites will be analyzed as received.

SIGNIFICANT RESULTS

There are no significant results to report in this period.

PUBLICATIONS

No publications were made in this period.

RECOMMENDATIONS

No changes in the program appear necessary at the present time.

DATA USE

Value of Data Allowed	Value of Data Ordered	Value of Data Received
$ 19, 300.	$ 4, 835.	$ 4, 835.

PROBLEMS

The analysis of the raw data tapes is presenting a problem, in that it was hoped that these tapes would answer questions about the MSS 6 and 7 data obtained from the corrected tapes. This analysis has taken much more time than anticipated, and due to the problems uncovered in two of three raw tapes, conclusive answers to the original questions have not been obtained.